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ABSTRACT

Provided are several perspectives on technology, addressing changes in learners related to technology, changes in contemporary life related to technology, and changes in subject areas related to technology (indicating that technology has created such new tools for inquiry as computer programming, word processing, online database searches, and collegial communication networks). Also provided are prospectives on the content of mathematics and science education, noting that, within the context of current educational reform, there is a fundamental shift regarding the purposes, audiences, and substantive content of science and mathematics education. For example, science today should be for all students, not just those few students who are talented and motivated for professional careers in science and engineering. Other areas addressed include: (1) current uses of technology (particularly computers) in mathematics and science education; (2) trends influencing the use of technology in education (considering demographic and economic transformation, declining cost of technology, economics of scale and market pull, integration of technologies, and accessibility of technology); (3) the computer as a tool; (4) levels of the mind (word processing, spreadsheets, and databases); and (5) suggestions for publishers. (JN)

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# TECHNOLOGY IN SCIENCE AND MATHEMATICS EDUCATION

by Alphonse Buccino[1]

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## INTRODUCTION: PERSPECTIVES ON TECHNOLOGY.

Thank you very much for inviting me to talk to you this evening. The three groups represented at this national conference, the Association of American Publishers, the National Council of Teachers of Mathematics and the National Science Teachers Association, are major actors in the drama of educational reform and improvement that our nation is addressing. I regard it as a distinct privilege to be here in such illustrious company. I propose to begin my remarks by offering some perspectives on technology that I hope will provide an indication of my own orientation to the problems and the issues.

After years of experiencing low priority, it is nice feeling for those of us in the field to find that education has become a high priority item again. Nevertheless, this is not a relaxing time for publishers or for science and mathematics educators. There are many forces influencing our situation in science and mathematics education today. Some of these forces are in

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conflict, some unclear in their effect. It is hard to plan, hard to know which way to go. At the same time, this situation presents an exciting challenge and opportunity. In my remarks tonight, I propose to discuss some of the forces that are influencing our planning and direction, and to suggest some general directions that we might take. I come to you as a kindred spirit. I have a special regard for books and in the search for educational scapegoats, publishers and educators are all in the same boat.

The problem of assessing the impact and potential of technology has been with us for some time. At the turn of the century, the biggest problem that existed in large cities like Chicago and New York was horses. The manure and the flies were building up. Citizens, the precursors of today's environmentalists, were concerned about dire threats to health and well-being. There was no satisfactory or feasible solution at hand. A significant cut-back in the number of horses in the streets did not appear to be likely. Nor were they likely to pay the price for more manure-shovelers. Here was an example of Garrett Hardin's "Tragedy of the Commons."

In 1903, Henry Ford opened the first assembly line producing the Model-T. In 1904, a substantial number of gasoline stations in America went bankrupt, and the New York Times ran an editorial saying that the automobile would never catch on. The network of service stations, streets, and highways needed to make it succeed was too complex and expensive to imagine. Nevertheless, just a

few years later, our cities were saved from the health hazard of the horses by the automobile.

The point here is that we might overlook or underestimate the impact of technology. One reason we might miscalculate regarding technology in education is that we may not take into account all the factors. As regard curriculum, and the relevance of technology to it, it is useful to consider an important contribution of Ralph Tyler. Of his many contributions to the field of education, one was his formulation of a rationale for curriculum development. Embedded in this rationale is the description of three "sources" for curriculum objectives: studies of learners, studies of contemporary life, and suggestions from subject-matter specialists. The entire rationale, along with the emphasis on the necessity of considering these three sources, has been extremely popular in the field. In fact, one could say that most theorists take the necessity to consider the three sources of objectives identified by Tyler as a fundamental premise of the curriculum field. Therefore, attempts to discuss science curriculum for schools today should be grounded in a re-examination of those three sources: learners, contemporary life, and developments in the substantive content of science.

## Changes In Learners Related To Technology

In a recent publication Decker Walker (1985) has identified several major changes in the way students -- the learners, the first of Tyler's three "sources" -- are affected by technology. Students today have an increased exposure through TV and other

media to a wide range of visual and auditory experiences. Their expectations and values have been influenced by technology. For them excitement is routine; they expect it. They have considerable experience as consumers. Also, some fundamental personality traits have been influenced by technology. The threat of nuclear destruction -- a by-product of very sophisticated technology -- colors their world views and even affects their sense of security for the family.

However, probably the most profound effect of technology on learners is the change in our concept of the very nature of intelligence. It is becoming increasing clear that, as Olson (1985) suggests, "intelligence is not simply a basic quality of mind, but must be seen as a product of the relationship between the structures of mind and ... cultural devices that one uses to think with." (p. 5). In particular, cultural devices -- communications and computing technologies -- alter the knowledge base of the thinker and the operations applied to that knowledge base.

One of Olson's major points is that computers require making meanings explicit. This requirement also is associated with written language, but computers substantially raise the degree to which explicitness of meaning must be addressed. Accordingly, literary competencies are basic to computer competencies, and the latter must build on the former. We will return to this point later.

What this will mean in regard to our conceptions of intelligence is still being explored, but some speculate that

computers and associated technologies will extend the basic separation between meaning and representation even beyond that stimulated by the written word.

Thus, learners will be required to make even clearer distinctions between what is represented in symbolic forms and what is added by the reader or listener. Literary competencies -- such as making meanings explicit -- and interpretation skills will take on an even more important role in our newer concept of intelligence.

In addition, it seems clear that we will have even greater resources in the form of organized and extended memory as well as organized "planned actions" (for example, algorithms and decision structures) (Olson, 1985). Because of these added resources, retrieval will increase in importance, and retrieval of operations may become as important as retrieval of knowledge. It seems clear, therefore, that because of technology the way we conceive of intelligence of learners is qualitatively different today and will change even more dramatically in the future. The potential significance of this on human evolution might be gauged by contrasting this with Julian Jaynes' analysis of the impact of written language on the evolution of consciousness (Jaynes, 1976).

Changes In Contemporary Life Related To Technology

Walker has also identified some major "changes in contemporary life" -- the second of Tyler's three sources -- that he links to developments in technology. These could be grouped into three categories: changes in business and industry, changes

in social relationships, and changes in institutions. With regard to business and industry some of the most significant recent changes resulting from technology are:

a. the shift in the work force to information-related occupations.

b. the rise in multinational corporations.

c. deregulation and restructuring of major consumer systems, such as communications and banking.

d. industrialization of farming.

e. an increase in service industries.

Technology also has had a significant impact on social relationships. Some of the most notable of these impacts are:

a. the increase in two income and single parent families. Part of this increase can be related to flexibility in work arrangements made possible through technology and the demands of a technological society for talent. A larger part can be attributed to personal demands related to a spiriting standard of living driven by technology.

b. population mobility related to rapid industrial developments which required an experienced manpower for startup.

c. increase of leisure time.

Institutions have also been affected by changes in technology. Some of these changes that most significantly affect schools are:

a. increasing influence of legislatures and courts resulting from the need for regulation and arbitration that comes from the increased interconnectedness of a technological society.

b. increased involvement of business and industry in training and education.

c. loss of influence of community and religious organizations to a media culture.

Changes In Subject Areas Related To Technology

Many analysts have called attention to some of the major trends in disciplinary knowledge -- in content -- related to changes in technology. Changes in this area are part of the third of Tyler's three "sources", suggestions from subject matter specialists. The most often cited factor is the exponential growth of knowledge (Saylor, Alexander, & Lewis, 1981, p. 139). Less spectacular but of great importance for curriculum is the change in disciplines themselves -- redrawn disciplinary boundaries and the creation of new disciplines -- which provide a whole new map for curriculum organization. Examples are cognitive science, genetic engineering, and agricultural economics.

Finally, technology has created new tools for inquiry. Examples are computer programming, word processing, data management, data analysis packages, use of graphics, online data bank searches, and collegial communication networks. This has had a great impact on many fields. Meteorology, for example, has

become truly a science as a result of the new capacity its practitioners have to handle the requisite large volumes of data.

A related perspective is based on observations of John Henry Martin. He asserts that a major factor driving the nature of usage of technology in schools is the almost universal assumption that technology and its unique materials should be used as a supplement to the teacher and the textbook. The concept of technology as a primary delivery agent has rarely been addressed. In other words, the manner in which technology has been used by the schools has predestined it to perform only a minor and subordinated role. Accordingly, the situation could change significantly if we examine technology's intrinsic potential, and not be constrained by our preconceptions.

Now let me describe the characteristics of one of my favorite educational technologies:

- Makes sounds and casts light, but audible and visible only to person using it.
- Starts automatically when you look at it.
- Stops automatically when you cease to look at it.
- Can play forward or backward; quickly or slowly; by skips or with repetitions.
- Deals with any of an infinite number of subjects.
- Self-contained.
- Portable.
- Non-energy consuming.
- Private and controllable.

A book has these characteristics. I want to start this way to remind us that the book, that much criticized technology, endures because it has so many characteristics desired of an educational technology.

## PERSPECTIVES ON THE CONTENT OF MATHEMATICS AND SCIENCE EDUCATION.

Within the context of the current wave of educational reform is a fundamental shift regarding the purposes, audiences, and substantive content of science and mathematics education. In the Sputnik era, the aim of science education was to prepare the relatively small cadre of professional scientists and engineers. Today, the concern is with a different group. Today, we call for science for the many, not just the few students who are talented and motivated for professional careers in science and engineering. This is stated most emphatically by the National Science Board Commission on Precollege Education in Mathematics, Science, and Technology in its 1984 report:

> We must return to basics, but the "basics" of the 21st century are not only reading, writing, and arithmetic. They include communication and higher problem-solving skills, and scientific and technological literacy -- the thinking tools that allow us to understand the technological world around us.
>
> These new basics are needed by all students -- not only tomorrow's scientists -- not only the talented and fortunate -- not only the few for whom excellence is a social and economic tradition. All students need a firm grounding in mathematics, science, and technology.

As emphatically as this new aim for science education and this new audience are affirmed, it is much less clear how they ought to be reflected in curricula and instructional materials.

Some argue for "applications," the incorporation of engineering and technology concepts into the science curriculum that today emphasizes the academic structure of scientific disciplines. This may provide an opportunity for relating mathematics and science more closely as the calls for more applications in science are matched by an emphasis on problem solving in mathematics.

Others argue for an emphasis on the "social impacts of science" as an organizing principle for new science curricula. This creates even greater difficulty for curriculum developers and publishers than the applications emphasis does, because of the value-laden nature of issues of social impacts of science.

The book of source materials accompanying the aforementioned National Science Board Commission report contains the following summary for the proposed K - 12 science curriculum:

- o Science and technology education daily in every precollege year.
- o Emphasis in grades K-6 on phenomena in the natural environment, collecting and processing data, a balanced physical and biological science program.
- o Emphasis in grades 7-8 on biological, chemical and physical aspects related to the personal needs of adolescents and to development of quantitative analysis skills.
- o Emphasis in grades 9-11 on the application of science and technology to the improvement of the community, local and national.

- o Options in grades 11-12 for discipline-oriented career preparation courses, preferably with several disciplines taken each year rather than one science subject each year.
- o Grades K-11 program be an integration of science and technology and practical mathematics.
- o Introduction of concepts of technology, such as feedback, alongside concepts of science.
- o Curriculum be organized around problem-solving skills, real-life issues, and personal and community decision making.
- o Research in teaching and learning be applied to identify desirable characteristics of curricular materials and teaching methods.
- o Coverage of what is basic in contemporary science and engineering concepts and methods.
- o Provision for interaction with the community and with informal education centers.
- o Implementation of the above curriculum in stages as new material and qualified teachers become available.

The recommendations for mathematics are parallel to those for science in calling for more mathematics for more students, but <u>different</u> mathematics from what is now in the curriculum. The following recommendations are made for the elementary and middle school:

- o That calculators and computers be introduced into the mathematics classroom at the earliest grade practicable. Calculators and computers should be

utilized to enhance the understanding of arithmetic and geometry as well as the learning of problem-solving.

- That substantially more emphasis be placed on the development of skills in mental arithmetic, estimation, and approximation, and that substantially less be placed on paper-and-pencil execution of the arithmetic operations.
- That direct experience with the collection and analysis of data be provided for in the curriculum to insure that every student becomes familiar with these important processes.

For high school mathematics the recommendations are:

- That the traditional component of the secondary school curriculum be streamlined to make room for new topics. The content, emphases, and approaches of all the courses need to be re-examined in light of new computer technologies.
- That discrete mathematics, statistics, probability, and computer science now be regarded as "fundamental" and that appropriate topics and techniques from these subjects be introduced into the curriculum.

One consequence of these recommendations for high school mathematics is that there is a need for alternative programs, and not just changes in the present courses. At least one program track is needed in addition to the current college bound,

non-college bound dichotomy. We need to reconsider the alternatives available for the so-called non-college bound and fill the gap between the college preparatory and essentially remedial curriculum.

## CURRENT USES OF TECHNOLOGY IN MATHEMATICS AND SCIENCE EDUCATION.

In this section I provide a summary listing of current uses of computers in science and mathematics instruction. Larry Hatfield's paper in the 1984 Yearbook of NCTM, "Computers in Mathematics Education," and James R. Okey's paper, "Integrating Computing Into Science Instruction" have been my main sources. Many of the sessions of this conference will no doubt discuss several of these items. In any case, here is my list:

- o Student Programming.
  - -- Development of algorithmic solutions for problems in science or mathematics classes.
  - -- Collect, assemble, manipulate, print, and display data from investigations.
- o Computer-Based Instruction.
  - -- Drill and practice.
  - -- Tutoring (e.g. introduction or overview; explanations or examples; questions).
  - -- Simulations.
  - -- Gaming (a special type of simulation).
  - -- Demonstration (generation of examples illustrations, counterexamples).

-- Testing of students (computer-based evaluation and feedback).

-- Information access, expanding resources of the classroom and laboratory by direct access to scholarly materials and databases.

-- Communicating (electronic mail, bulletin boards).

o Teacher Utilities (for planning, managing, evaluating, and reporting on instruction).

-- Classroom and instructional management; individualization of content, objectives and pacing, record-keeping.

-- Generation of curriculum materials using print and graphics.

-- Test generation, scoring and analysis of test data.

-- Communications.

TRENDS INFLUENCING THE USE OF TECHNOLOGY IN EDUCATION.

Let me turn now to looking ahead a little to what lies on the horizon regarding the use of technology in education. To begin with, I think there are important forces -- I will identify five -- influencing the use of technology in education.

Demographic and Economic Transformation. I believe that we will soon confront strong pressures which will force a transformation in education. This will be, quite literally, a change in the way we organize and deliver what we do in the schools. This change is being forced, in part, by demographics. School enrollments are slowly increasing at a time when there is

a larger than usual exodus of teachers from the schools and a reduced size of the pool from which newly graduated teacher are to come. Members of the first wave of post-war baby boom teachers are retiring. Meanwhile, the eighteen-to-twenty-four year old cohort is declining as a percent of the total population, and this statistic does not reach bottom until 1995. Accordingly, we are now beginning to experience teacher shortages which will become acute in the early 1990s. (To be sure, this is from a national perspective and there may be regional differences.)

The other factor that will force a transformation in education is economic. Education is a labor intensive enterprise which means that the cost of education, as a proportion of GNP or state product, keeps rising. This will accelerate as a result of increased salaries for educational personnel in Georgia and elsewhere. As a result of this phenomenon, the public will have the sensation of paying more for education and getting less. (Remember, the feeling in 1973, when the sharp rise in gasoline prices suddenly increased the cost of transportation for all of us, while we were not travelling any more than we usually did?)

Declining Cost of Technology. Meanwhile, alongside shortages and increased costs for educational personnel, we are seeing declining costs for technology. Consider what has happened with the video-cassette recorder (VCR). When first introduced on the market about five years ago for about $1,000, sales were sluggish and there were reports of full warehouses and lost fortunes. More recently, the VCR became the technology of

the year and many of us have them in our homes. Indeed, teachers and other professionals in this audience (even some of you who will claim to be hostile toward technology in education) are now using home VCRs for professional purposes.

The same thing is happening with other technologies, such as the computer. More and more of us are acquiring and using microcomputers at work and at home.

Economies of Scale and Market Pull. The micro computer, Apples and Pets, initially hit the school scene in about 1977-78. From that time, until recently, the microcomputer in the school has been the result of the PTA bake sale mentality. But now, more and more states and other large educational jurisdictions (e.g. New York City, Los Angeles, Houston, Atlanta) are recognizing that, with the accumulation of microcomputers in the schools, there is an advantage to state-wide or system-wide purchasing agreements. Suddenly, the market for one or two microcomputers resulting from the PTA bake sale has shifted to significant large-scale market of considerable interest to industrial giants such as IBM and AT&T.

Integration of Technologies. Another significant development is the integration of technologies. Now, the silent flat-screened computer and monitor are being superseded by the incorporation of sound, color, and graphics. An especially interesting development is the integration of telecommunications and computer technologies into computer networked systems. These are about to be marketed by IBM and AT&T on a very large scale. Hardly any industry has been interested in education as a market,

but all of a sudden giants like IBM and AT&T not only see a market in education that industry has never seen before. Moreover, the market and profit impulses are being reinforced by a spirit of altruism that these integrated technology systems will actually improve education.

Accessibility of Technology. The fifth factor is the increasing accessibility of technology. We have already referred to the ubiquity of the VCR, but there are other developments. When teachers had to wheel the TV set or film projector into the classroom on a cart from down the hall or even from another floor, that was a severe constraint on the use of TV in instruction. But now, the number of classrooms with a permanently installed TV monitor (and VCR!) is increasing rapidly. Moreover, the Georgia Department of Education has a program to equip every school in Georgia with 1,200 cassettes of the best television and film materials, and a media specialist to help manage this library. Having the technology at one's elbow is a great facilitator of its use, in comparison to having to queue up for it.

THE COMPUTER AS A TOOL.

From my sit of current uses of the computer in instruction, one can distinguish the use of the computer to deliver instruction -- what is called computer assisted instruction (CAI) -- and the use of the computer as a tool, like the pencil or the notebook, or the telephone. CAI has not lived up to many early expectations. To be sure, its use in drill and practice has been

successful, but extension of CAI to higher level tutorial instruction has generally not been so successful.

On the other hand, the computer as a tool has indeed made its mark. The business office has been transformed by the computer, and so has the management and administration of education at all levels. It is hard to imagine budgeting, scheduling, grading, and record keeping in schools, colleges, and universities without the computer. But this tool use extends to instruction if we consider such things as word processing and the record keeping by an individual teacher.

Indeed, the tool use of the computer has grown extensively in higher education. Many college and university students and faculty now take the computer for granted and use it extensively as a tool to get their work done. This tool use of the computer (compared to programming and computer literacy) has not yet impacted so greatly on elementary and secondary education, but there are signs that it is coming. There is a second grade class near the University of Georgia where the pupils regularly publish a newspaper and a magazine with their micro computer based word processor. Mark Tucker of the Carnegie Forum on Education and the Economy developed this argument for an audience very similar to this one (under AAP auspices) just a year or so ago. I want to carry Tucker's argument a step further.

LEVERS OF THE MIND.

What drives the computer-as-tool is what I call levers of the mind. The three ubiquitous levers are word processing,

spread sheets, and data base system programs. These so clearly and effectively extend human capabilities that everyone grasps their value instantly. These three "levers" occur extensively in what I have called the "tool use" of computers. These three levers -- word processing, spread sheets, and data base programs -- are already being used in instruction in a variety of clever ways.

But further use of the computer as a tool in education will occur as we develop new "levers of the mind." There are indications that this is happening with Judah Schwartz's Geometric Supposer, the MIT MACSYMA program and the MuMath disk.

The Geometric Supposer (say, for triangles) allows one to make any of the ruler and compass constructions, any of the associated calculations, and store information. For example, one can construct the angle bisector of a triangle, then measure the distance along it to the opposite side, and store the number for future reference. Recently, Leone Burton has identified four processes of mathematical thinking: specializing, conjecturing, generalizing, and convincing. It is easy to see how the Geometric Supposer can be used to implement these processes and carry out manipulations that lead to getting a sense of pattern.

MuMath is a powerful symbol manipulator, somewhat new in its availability to a large audience. In contrast to the symbol manipulator, all of us are familiar with the type of computer programs that perform numerical calculation. These are programs where one puts in a number or set of numbers and the computer

puts out another number or set resulting from the calculations carried out by the program.

But the new programs, like MuMath, carry out symbolic manipulation of mathematical expressions. For example, MuMath will take the input:

?DIF(X*SIN(X),X)

which asks to differentiate xsinx with respect to x. It will then display:

@X*COS(X) + SIN(X).

Programs that can do this are not new. What is new is the recent mass availability at relatively low prices of programs with these capabilities that can run on individually owned micro computers. MuMath is one such program. The availability of these capabilities in pocket computers is not very far way.

Some elementary questions arise immediately. Will we allow students to bring them into exams? Use them to do homework? But there are even more difficult questions. How will the content of, for example, calculus courses be affected? Will college and university teachers take the advice that they have been dispensing to school teachers, that they should teach more of concepts and less of mechanical manipulation? The answers are not yet at hand, but the questions indicate that something profound is going to have to happen.

## CONCLUDING COMMENTS AND SUGGESTIONS.

In closing, I want to make a set of about six comments and suggestions that are more or less on the order of actions that

might be taken, especially by publishers. The six are roughly ordered from the most immediate and simple to the more complex.

Standardized Cataloging. At present, it costs about ten dollars to get a book ready for the shelf in the library or media center after it has been received. If progress can be made in the standardizing of the process of cataloging, substantial economies are possible.

Curriculum Alignment. More and more states are setting curriculum or competency requirements to be addressed by all schools in the state. This is leading to demands for "road maps" or information systems to align curricula with instructional materials. Very soon, in adoption states, publishers will be asked to provide information on how the materials being submitted for adoption "map" against state requirements.

Co-Development. In a recent policy paper on the use of technology in education, Levin and Meister recommend co-development as a potentially significant step toward overcoming the lack of incentives for software development. This idea is based on the notion of a partnership between a software developer and a school district or consortium of school districts. A variation on this idea is being promoted by the National Science Foundation. A recent program solicitation for elementary school science instruction encourages partnerships among publishers, school systems, and developers of instructional materials.

Videodisk for Reference Materials. Interactive videodisk has been the technology of tomorrow for several days now. Its

significance in education has not developed anywhere nearly as quickly as its proponents have often suggested. Nevertheless, this technolgy continues to advance. It is interesting to note that CD (compact disk) technology has taken hold for home music enthusiasts. But CD and videodisk are basically the same technology -- indeed, there is already a product on the market that plays both the audio CDs and videodisks. Increasingly, we here of this technology in terms of ROM (read-only-memory) disks. As hardware systems become available at acceptable cost, this technology is going to be the technology of choice for reference materials, encyclopedias and the like.

Integrated Learning Systems. There is a growing need to correlate (if not integrate) instructional materials, notably textbooks, computer software, and television materials. The curriculum alignment phenomenon I mentioned earlier is going to require that developers display the linkage of textbooks to computer software or television materials. As Mark Tucker put it, the job of publishers will continue to be the creation of instructional materials in print form. But now, publishers must assume computers will be available to students as well. I predict that publishers who make only a nominal charge for the computer disk materials included as integral parts of textbooks will set the pace on textbook sales. In due course, the simple correlation of materials in different forms will foster the increased use of more sophisticated integrated learning systems I mentioned in the previous section. We may even get to the really sophisticated point of John Henry Martin (also referred to

earlier) where integrated technology systems are no longer viewed as supplements to teachers and textbooks, but are utilized as primary delivery agents.

New Formats for the Delivery of Materials. We all agree that the time line for book publishing is too long. Moreover, textbooks are difficult to update. The technologies at hand make possible totally new and different formats for the delivery of materials. The Business Section of the New York Times on February 2, 1986 has a profile of Joseph L. Dionne, McGraw-Hill's president and chief executive, and his commitment to new electronic products as essential for the corporation to flourish. To be sure, it is easier to see the direction of electronic publishing in fields other than education, but education will also be affected by the electronic information revolution. Jack Taub's National Information Utility represents one concept for broaching this market.

These developments are having other consequences. For example, we will need to be considering the leasing of equipment and materials, rather than purchase. Licensing and copying agreements are becoming more commonly used. Georgia is leading the way in signing licensing agreements with producers of television materials and computer software developers. Basically, these agreements reduce the unit price of the materials. Our early experience in Georgia is impressive. Everyone is happy. The schools have a great deal more material available at a very low price. At the same time, the producers have much lower sales and distribution costs and phenomenally

higher volume. A step beyond this is the "metering" associated with the National Information Utility.

For all these reasons, these are exciting as well as challenging times. I would encourage publishers, especially, to enter into experiments, either individually or through AAP. Rather than have a strict separation between publishers and users, we need more partnerships to conduct experiments to test new ideas for coping with the phenomena I mentioned. Fostering the development of partnerships and user support systems can be done instead of developing an in-house capability, and, so, need not increase costs for publishers.